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EFFECTIVE METHOD OF SERVICE LIFE EXTENSION FOR GLASS FURNACES

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A technology has been developed for high-temperature ceramic welding for the purpose of repairing the lining in glass furnaces without stopping and cooling the furnace. This maintenance method makes it possible to restore damaged refractory articles and, if necessary, to change their properties toward higher heat-resistance as well as resistance to corrosive media and mechanical actions. The main and auxiliary equipment for ceramic welding have been developed and repair pastes for restoring different types of refractories obtained.

Key words: hot repair, glass furnace, ceramic welding, furnace inspection.

Timely and quality repair is the key to extending the service life of glass furnaces. One of the modern and most effective methods of hot repair is ceramic welding. This method makes it possible to perform both prophylactic and major hot repairs on glass furnaces. The advantage of this type of repair is that the technological regime and the productivity of the furnace are not disrupted and product quality is not lowered. In recent years the ceramic welding method has received the recognition it deserves. At the present time the ceramic welding technology has been successfully adopted and is being used effectively at leading Russian glass plants. Thus, the experience of enterprises using this repair technology shows that this type of maintenance increases the service life of glass furnaces by years.

The principle of ceramic welding is fusion in a wave of combustion of refractory material directly on the surface of the lining being repaired (Fig. 1). A considerable amount of heat is released as a result of the combustion reaction, which results in melting of the surface layer of the lining. As it cools to the working temperature combined crystallization of the fused material and the surface layer of the masonry occurs. Thus, the damaged section is restored and the crystal structure, chemical composition, and physical properties of the ceramic fusion seam itself are close to those of the refractory material. The formation of a strong interatomic bond owing to combined crystallization guarantees that the sections repaired by this technology will remain stable for many years.

The destruction of individual structural elements of the melting tank and gas space often limits the service life of a furnace, but the ceramic welding method makes it possible to solve these problems. Just ten years ago only dinas lining of the roof was subject to repair, whereas now practically any zones of the top structure of a furnace can be repaired by ceramic welding. This was made possible by the development of special equipment, repair materials used for different purposes, and new technological techniques.

A special facility was developed to guarantee the conditions required for fusion of refractory material in a wave of combustion. The apparatus makes it possible to feed the ceramic repair paste at a prescribed rate in an oxygen medium along a flexible tube and a lance to the fusion site (Fig. 2).

While making the repairs by ceramic welding it is difficult for the operator to monitor the fusing process, if the sec-

Fig. 1. The ceramic fusion process.

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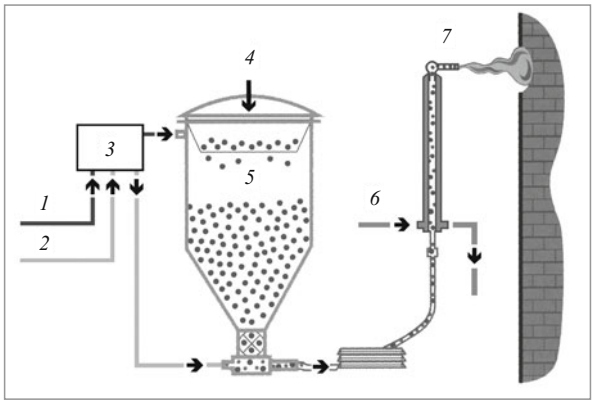

Fig. 2. Process scheme of the ceramic fusion process: *1*) nitrogen; *2*) oxygen; *3*) panel; *4*) repair material; *5*) hopper; *6*) water cooling; *7*) lance.

tion undergoing repairs is remote or is located outside the directly visible zone. A video observation apparatus was developed to solve this problem; this apparatus greatly facilitates the ceramic-welding operator's work and makes the repair process more efficient. The water-cooled endoscope introduced into the furnace operates at ambient temperature to 1700°C and makes it possible to obtain on a monitor screen a color image of the lining. Depending on it modification the camera can be pointed at angles 0, 45, and 90° or 0, 60, and 120° with respect to the axis of the endoscope; this gives a screen image of the furnace zones which are not accessible for visual examination through the service openings in the furnace. The endoscope made it possible to evaluate the state of the furnace roof, the walls of the flame space, and the checkerwork of the regenerator as well as to monitor the integrity of the lining. Constant monitoring of the furnace lining makes it possible to detect and eliminate defects in the refractory in a timely fashion, so that the situation does not become critical.

Since the key to high-quality repairs of the lining by means of ceramic welding is that the ceramic layer fused on is identical to the refractory, the following problem was posed: to develop different ceramic pastes for restoring different kinds of refractories.

Scientific investigations yielded a series of materials for performing repairs by the ceramic fusion method. Thus, a ceramic paste for restoring the dinas lining of glass furnaces was developed. The physical-chemical properties of the fused ceramic layer (FCL) are close to dinas articles for the masonry in glass furnaces (see Table 1).

This repair paste has proven itself well and has already been in use for many years in glass plants for repairing different elements of the top structure: main roofs, suspended walls of the flame space, regenerators, arches of the feed containers, and so on.

In recent years, in addition to dinas articles, baddeleyite-corundum articles, which are more corrosion-resistant to the volatile components in batch, have been increasingly used in

TABLE 1. Properties of a Fused Ceramic Layer (FCL) and Dinas Refractory

Indicator	FCL	Dinas refractor
Mechanical and thermal properties:		
apparent density, g/cm^3	1.84	1.73 – 1.85
actual density, %	2.35	2.33 – 2.38
open porosity, %	19.20	< 22.00
thermal conductivity at 1000°C, W/(m · K)	1.50	1.70
ultimate strength under compression in the cold state, MPa	20.00	> 21.00
softening onset temperature, °C, not less than	1650	> 1650
Chemical composition, wt.%:		
SiO_2	96.20	96.0
CaO	1.80	2.0 – 3.0
Fe_2O_3	1.20	< 1.70

the top structure of furnaces. Unlike dinas refractories, fusion-cast bacor refractories have high resistance to corrosive media, low open porosity, high mechanical strength, and high heat-resistance, which is why they are placed in masonry zones subject to high wear in a glass furnace.

A ceramic paste has been developed for repairing bacor sections of the lining of glass furnaces. The properties and composition of fusion paste are close to those of bacor articles placed in glass furnaces. This is confirmed by different chemical and physical methods of analysis, such as elemental analysis, x-ray phase analysis, scanning electron microscopy, and others. This ceramic paste is used to restore the arches of the loading containers, teeth, burner inlets, as well as the walls of the melting tank above the surface level of the molten glass. Practice has shown that this repair paste forms on the surface of restored lining a protective fusion ceramic layer that greatly improves the corrosion resistance the repaired sections.

A ceramic paste for restoring fireclay refractory has also been obtained. A long service time of a repaired section is obtained by the fact that after fusion the repair paste reproduces all the main properties of the refractory.

A composition for repairing periclase refractories by the method of ceramic welding was developed in the course of scientific studies. This material has been successfully tested.

The advantages of the technology of ceramic welding, such as no disruptions of the production cycle, speed and simplicity of application, and a long service life of the repaired sections, have made this method of restoring lining quite popular. In-house teams performing hot repairs on furnaces by ceramic welding using the materials and equipment developed have now been created at nine large glass plants in Russia as well as at enterprises in Kirgizia and Portugal, making it possible to take effective, timely measures to extend the service life of glass furnaces.